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The Absorption and Translocation of the Systemic Insecticide Schradan in Sitka Spruce and Grand Fir

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ABSTRACT

Rediske, J. H. and Norman E. Johnson. (Weyerhaeuser Company, Forestry Research Center, Centralia, Washington). The absorption and translocation of the systemic insecticide Schradan in Sitka spruce and grand fir. Weyerhaeuser Forestry Paper No. 5. 1965. Schradan tagged with P^{32} was tested on seedlings grown in nutrient solutions in a controlled-environment chamber. Sixty ppm Schradan in the nutrient solution was absorbed in greatest amounts in the current foliage after 16 days (3.5 ppm in spruce) with old foliage, bark and wood in decreasing order. Schradan applied to terminal buds was shown by autoradiographs to be absorbed and translocated down the main stem and into lateral branches.

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The use of systemic insecticides for the control of insects on forest trees offers advantages unattainable with contact chemicals. The timing of application of systemic chemicals, for example, is not as critical; if insects have already begun to feed, the systemic will translocate into the tree and reach them. On the other hand, contact insecticides, to be effective often have to be applied with precision in timing so that they kill the insects before they penetrate the plant. When systemics are injected directly into a tree, they protect it from insects that feed directly on or in it. At the same time, they do not harm other organisms that come into casual contact with the tree. By injecting the individual trees with systemics, many of the problems associated with broadcast application of contact chemicals are practically eliminated.

Rudinsky (1959) summarized the pioneer work with systemic insecticides for the control of insects affecting forest trees. More recently systemics were tested against cone and seed insects by Hedlin (1962) and by Johnson and Rediske (1964). Coppel and Norris (1961) tested several systemic insecticides against the sawfly, Diprion similis. Norris (1961, 1962) tested and found effective several systemic insecticides for control of bark beetles feeding on elm twigs.

The use of systemic chemicals for forest protection will assuredly grow. Before significant progress can be made, however, information is needed on the movement and distribution of the systemic chemical within the plant. The purpose of this study was to obtain such information for the systemic insecticide Schradan in Sitka spruce

(Picea sitchensis (Bong.) Carr.) and grand fir (Abies grandis (Dougl. Lindl.). We were particularly interested in determining whether or not the systemic chemical would reach the tissues fed upon by the Sitka spruce weevil (Pissodes sitchensis Hopk.) and by the balsam woolly aphid (Adelges piceae Ratz.) in spruce and fir, respectively.

MATERIALS AND METHODS

Sitka spruce seedlings (2-2 nursery stock) were transferred to a nutrient culture of normal Hoagland's solution. Seedlings were grown in a controlled-environment chamber for 8 weeks; by the end of this period, roots and shoots of all seedlings showed new growth. During the 8 weeks, day dry-bulb temperature was kept at 30°C and wet-bulb at 20°C; at night, dry- and wet-bulb temperatures were 20°C and 15°C, respectively. Root temperature was maintained at 17°C and light intensity was 1200 foot-candles.

At the end of the 8-week period, the seedlings received one of two treatments. To one group, 60 ppm of Schradan were added to the nutrient solution which contained 36 microcuries per liter of P^{32} in the form of tagged Schradan. These plants were harvested at 4, 8 and 16 days after treatment. Tissue samples were taken from the youngest needles and wood, from older needles and from bark and wood of the lower stem. These were analyzed by tracer techniques for Schradan content. Following the procedure of Rediske and Shea (1961), an autoradiogram was also made from the whole plant to show gross distribution. These plants were cut at the nodes before drying to prevent change in the distribution of Schradan.

To another group of seedlings, a 10 microliter aqueous solution containing 2.33 mg of Schradan and 2.93 microcuries of P^{32} as Schradan was applied to each of the terminal buds. These plants were harvested at 4, 8 and 16 days and prepared for autoradiograms as described above.

RESULTS

Figure 1A shows the results of tissue analysis of Sitka spruce trees that had grown for up to 16 days in nutrient solutions containing 60 ppm of Schradan. The highest Schradan concentration, and the greatest rate of its increase, were found in the youngest needles and the succulent stem tissue. These contained about 3.5 ppm of Schradan and were apparently still accumulating rapidly.

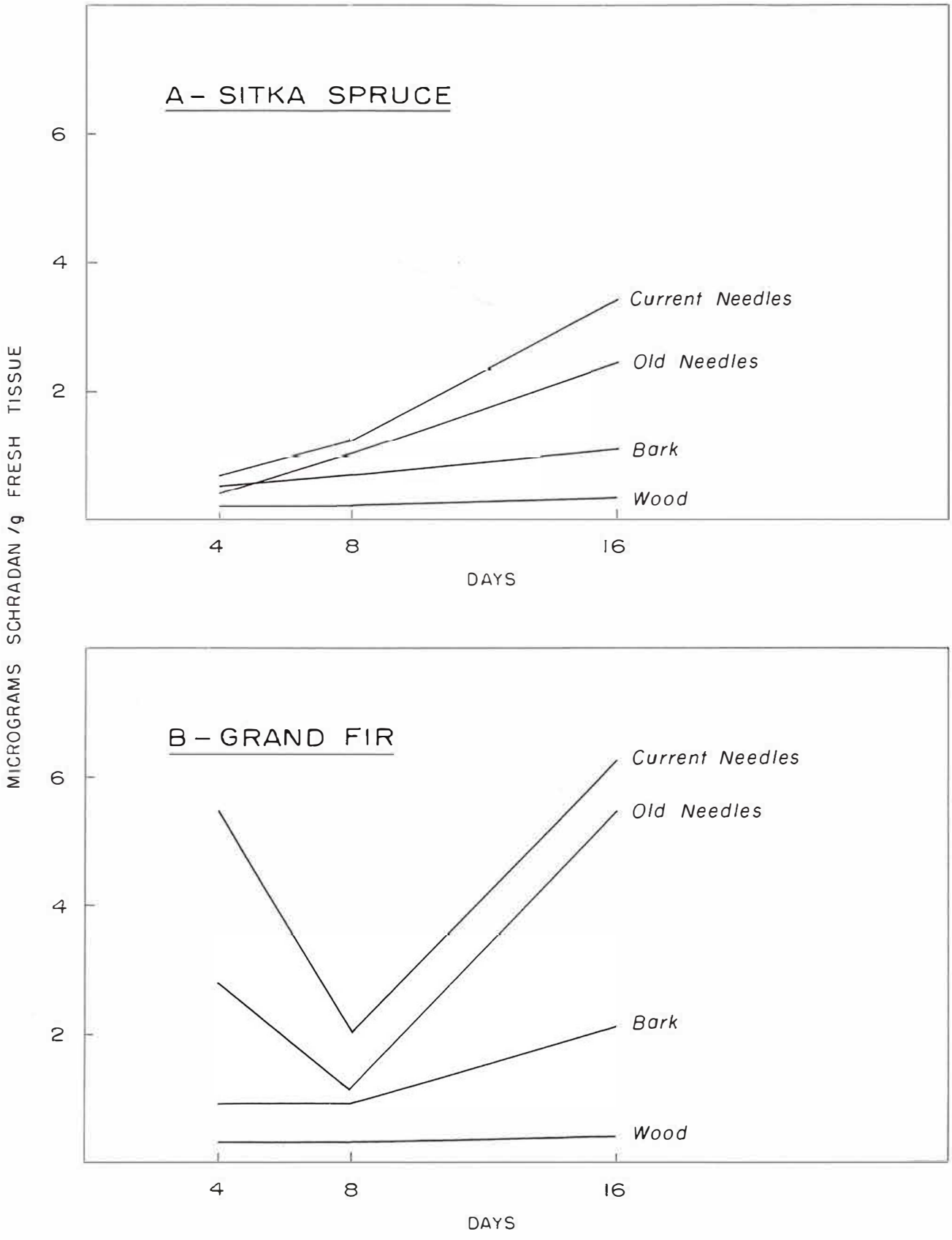

Figure 1. Concentration of Schradan in various tissues of Sitka spruce (A) and grand fir (B) seedlings.

The older needles also accumulated considerable Schradan, although to a lesser extent than the newer tissues did. Although the bark accumulated less Schradan than was found in the leaf tissue, the concentration increased significantly between the 8th and 16th day, indicating progressive movement of Schradan into the bark. In due course, the concentration in the bark might attain a level providing protection against insects. Apparently, only the wood did not continue to accumulate Schradan; its concentration at 16 days did not differ significantly from that at 4 days. Although there was an unexplained dip at 8 days for the grand fir data (Fig. 1B), the relative concentrations for the various tissues were similar to those for Sitka spruce.

The gross autoradiogram of a duplicate plant grown in nutrient solution containing Schradan tagged with P^{32} supports the above data. In Figure 2, the roots have the highest concentration but needles and new growth are well exposed, indicating a large concentration of Schradan. Even the stems show some exposure, primarily from the Schradan in the bark since the wood contained little.

Figure 3 shows an autoradiogram of a Sitka spruce seedling which had received an application of radioactive Schradan on the terminal bud. Absorption has occurred and the chemical has moved primarily to the lateral branches immediately below the point of application. As the Schradan moved down the stem, the concentrations found in the lateral branches at these lower levels were less. Even so, exposure is plainly visible in the lower stem, indicating primarily the Schradan that is in the phloem plus a significant amount being translocated to the roots. The cross sections of the stem to the right of the autoradiogram indicate that the distribution (a) in the upper stem is rather uniform, and (b) in the lower stem is confined to phloem tissue with a tendency to channel vertically. Similar patterns of exposure were observed in grand fir.

DISCUSSION

The distribution of Schradan from root absorption is such that current growth would receive the greatest protection with older needles next in order. Because of its distribution, Schradan should be particularly effective against needle-attacking insects. Since bark was still accumulating the chemical after 16 days, it is possible that this systemic would protect against bark-attacking insects, such as the balsam woolly aphid, as well. Thus, Schradan might be expected to provide protection against both the spruce weevil and the balsam woolly aphid.

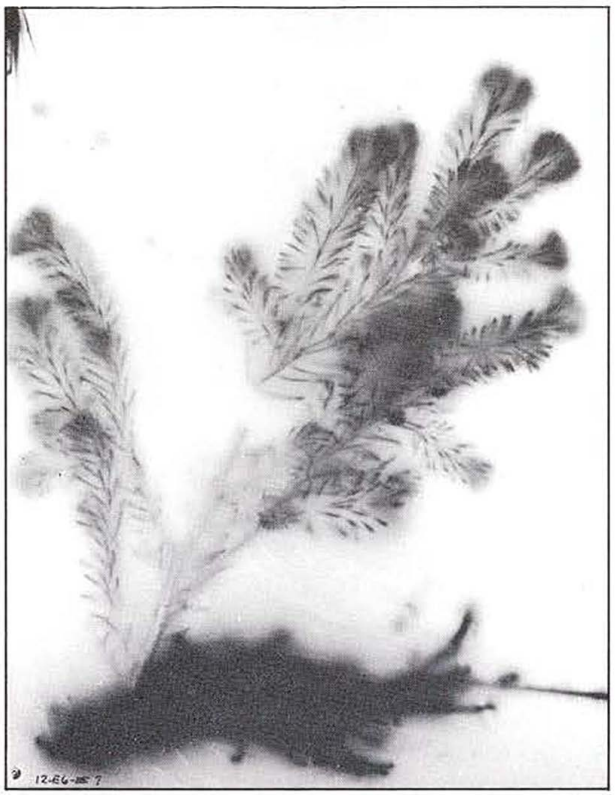

Figure 2. An autoradiogram of a Sitka spruce seedling after 8 days in a nutrient solution containing Schradan tagged with P^{32}.

Figure 3. An autoradiogram of a Sitka spruce seedling 16 days after an application of Schradan tagged with P^{32} applied to the terminal bud. Arrows point to stem cross sections.

In an unreported study from our laboratory[1], however, Schradan did not give complete control of balsam woolly aphid on potted grand fir seedlings; on the other hand, aphids of the genus Medarus, feeding on the foliage of the same trees, were completely controlled. It is apparent that distribution of Schradan by way of the roots is likely to be adequate to protect Sitka spruce from common insects.

Application to the crown appeared similarly promising. When Schradan was applied to the terminal bud, it concentrated in the new growth immediately below the point of application. Although it continued to move down, the lower the branches on the stem, the lower the concentration. Nevertheless, some chemical reaches the lower stem and the root and is plainly visible in autoradiograms in the phloem and in the cross sections of the stem. With a general application of spray, the distribution in the crown would probably be considerably more uniform.

Trunk implantation has been tried with balsam fir with some success (Giese, et al., 1958) but this method was not evaluated in this series of experiments.

It is apparent from the above work that the systemic insecticide Schradan can be applied either as a foliage spray or through the roots and that it will be absorbed and translocated into the new growth and needles of Sitka spruce and grand fir seedlings. The systemic moves into the bark, but more slowly than it does into the new growth, at least over the first 16 days.

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